IMPROVED WOOD-REDUCING APPARATUS WITH CONTINUAL FEEDER ASSEMBLY

CROSS REFERENCE TO RELATED APPLICATIONS

This application claims the benefit and priority of the following applications, each of which is incorporated herein by reference in its entirety: the U.S. Provisional Application bearing Serial No. 60/189,317, filed March 14, 2000; the U.S. Provisional Application bearing Serial No. 60/202,721, filed May 8, 2000; and the U.S. Non-Provisional Application bearing Serial No. 09/805,754, filed March 13, 2001, now U.S. Patent No. 6,575,066 B2.

FIELD

The material described herein relates generally to the field of wood and lumber processing and, more particularly, to the efficient reduction or cutting of scrap wood into useable chips.

BACKGROUND

Lumber mills and other wood processing facilities typically generate wood scraps of various sizes. In plywood processing mills, for example, the wood scraps can be in the form of thin, elongate, veneer-like strips. To be useful in the manufacture of paper, cardboard, and other recyclable materials, wood scraps must be reduced into wood chips having an acceptable size and shape. Mills use screens to separate acceptable wood chips from oversized wood chips. The oversized wood

chips are sometimes referred to as overs because they pass *over* the separating screens.

Ideally, the overs need to be reduced to wood chips that are relatively uniform in size, having gross dimensions of approximately one inch or less. The desirable chip size may vary, depending upon the intended use. Several different types of machines have been tried for reducing overs, such as disc chippers, drum chippers, chip hogs, and the like. These machines often crush or pulverize the overs into unusable bits that are unacceptable for use in making paper, for example.

Mills typically generate a nearly steady flow of overs during wood processing, creating a concomitant need for a system capable of processing overs continuously. The flow of incoming overs may vary greatly, from zero to a large batch, depending upon the mill operations. Most available systems are not capable of adapting to changing volumes without interrupting processing or requiring expensive manual labor when a system becomes jammed or overloaded.

The presence of metal objects in batch wood processing presents an ongoing challenge to facilities where equipment is both expensive and sensitive to damage from metal. The cost and delay of stopping a major piece of equipment to remove metal or repair the damage it caused represents an unacceptable expense for most facilities. Even small metal objects can cause significant damage, especially to grinders and chippers having an array of closely-spaced saw blades. The machinery in use, for example, to reduce overs into small wood chips may be particularly vulnerable to damage from small metal objects.

Thus, there is a need in the art for improvements for the task of safely reducing overs to an acceptable and useful size, efficiently and steadily, during ongoing mill operations.

SUMMARY

The following summary is not an extensive overview and is not intended to identify key or critical elements of the systems, methods, apparatuses, processes, and the like or to delineate the scope of such elements. This Summary provides a conceptual introduction in a simplified form as a prelude to the more-detailed description that follows.

Certain illustrative systems, methods, apparatuses, processes, and the like are described herein as examples in connection with the following description and the accompanying drawing figures. These examples represent but a few of the various ways in which the principles underlying the systems, methods, apparatuses, processes, and the like may be employed and thus are intended to include equivalents. Other advantages and novel features may become apparent from the detailed description presented later, when considered in conjunction with the drawing figures.

The above and other needs are met by the present invention which, in one embodiment, provides a system, method, and apparatus for reducing a continuous incoming flow of oversized wood chips known as overs by cutting them smoothly, with minor impact, so the resulting chips are suitable for making paper, cardboard, and other recyclable materials.

The examples described herein include an apparatus for reducing the size of wood chips. The apparatus may include a saw assembly having an array of blades disposed upon a shaft and configured to be driven at a cutting speed in a first rotational direction. The shaft may define a shaft interference zone. The apparatus may also include a feeder assembly configured to direct a flow of the wood chips along a feeder path, the feeder path passing into and through the array of blades. The feeder assembly may define a feeder zone at least partially intersecting the array of blades. The apparatus may also include a topper assembly positioned proximate the feeder path, the topper assembly located upstream of the saw assembly relative to the

feeder path. The topper assembly may be configured to reduce the height of the flow of the wood chips such that the flow of wood chips does not tend to extend into the shaft interference zone. The apparatus may reduce the wood chips into a plurality of cut chips.

The saw assembly may be positioned such that the shaft interference zone nearly intersects tangentially with the feeder zone.

The topper assembly may be positioned such that the topper zone nearly intersects tangentially with the feeder zone.

The saw assembly may further include an array of spacers disposed upon the shaft, with the spacers positioned alternately between the array of blades.

The feeder assembly may include one or more paddle assemblies configured to be driven along the feeder path at a feeder speed in a direction generally opposing the first rotational direction. Each of the paddle assemblies may define an array of slots therethrough, positioned to accept insertion of the array of blades.

The paddle assemblies may include a series of like paddle members. The paddle assemblies may be disposed upon a drum and the drum may be mounted upon a feeder shaft.

In one embodiment, the paddle assemblies may be mounted to an endless chain configured to be driven along an endless feeder path about one or more powered rollers, the endless feeder path comprising one or more either straight or curved segments, and the endless path may coincide with the feeder path at least during the flow through the array of blades.

The paddle assemblies may also include a scoop portion shaped to cradle the wood chips and a fence portion shaped to contain the wood chips during the flow through the array of blades.

The paddle assemblies may be shaped to align the oblong chips generally transverse to the array of blades in preparation for the flow through the saw assembly.

The fence may be further shaped to contain the wood chips in opposition generally to the wind force created by the saw assembly.

The topper assembly may include one or more topper blades disposed upon a shaft and configured to be driven at a topping speed in the first rotational direction.

The apparatus may further include a conveyor assembly providing an incoming flow of the wood chips.

The apparatus may also include a chute disposed in an engaged position to guide the flow of the wood chips toward the feeder assembly, the chute having a floor and a lower chute edge.

The chute may further include a chute actuator configured to move the chute relative to the feeder assembly between the engaged position and a disengaged position, the disengaged position characterized by the chute guiding the wood chips away from the feeder assembly; and a chute controller operably connected to the chute actuator.

The chute may further include a chute load sensor positioned along the chute near the flow of wood chips; the chute load sensor operably connected to the chute controller, the chute load sensor capable of transmitting at least a normal signal and a fault signal.

The chute load sensor may include a metal detector, and the fault signal indicates a metal object in the flow of wood chips.

In one embodiment, the chute actuator moves the chute into the disengaged position in response to a fault signal.

The apparatus may also include a dam positioned between the chute and the feeder assembly, the dam shaped to urge the wood chips toward the feeder assembly. The dam may include an inner face oriented toward the feeder assembly (the inner face shaped to nearly coincide with the feeder zone), a trailing dam edge, and a leading dam edge.

The dam may be stationary relative to the feeder assembly and the trailing dam edge may nearly meet the lower chute edge when the chute is in the engaged position. Where the paddle assemblies include an outer paddle face and a leading paddle edge, the dam may be positioned such that the outer paddle face nearly meets the inner dam face and the leading paddle edge nearly meets the leading dam edge.

In another example, an apparatus for reducing the size of wood chips may include a saw assembly having an array of blades disposed in spaced-apart relation upon a shaft and configured to be driven at a cutting speed in a first rotational direction, the shaft defining a shaft interference zone; a feeder assembly configured to direct a flow of the wood chips along a feeder path, the feeder path passing into and through the array of blades, the feeder assembly defining a feeder zone at least partially intersecting the array of blades, wherein the saw assembly is positioned such that the shaft interference zone nearly intersects tangentially with the feeder zone; a topper assembly positioned proximate the feeder path, the topper assembly located upstream of the saw assembly relative to the feeder path, the topper assembly configured to reduce the height of the flow of the wood chips such that the flow of wood chips does not tend to extend into the shaft interference zone, the topper assembly defining a topper zone, the topper assembly positioned such that the topper zone nearly intersects tangentially with the feeder zone; and a chute disposed in an engaged position to guide the flow of the wood chips toward the feeder assembly, the chute comprising a floor and a lower chute edge, the apparatus reducing the wood chips into a plurality of cut chips.

In another example, an apparatus for reducing the size of wood chips may include the elements described in the immediately-preceding paragraph and, in addition, a dam positioned between the chute and the feeder assembly, the dam shaped to urge the wood chips toward the feeder assembly, the dam comprising an

inner face oriented toward the feeder assembly, the inner face shaped to nearly coincide with the feeder zone, a trailing dam edge, and a leading dam edge.

In another example, an apparatus for reducing the size of wood chips may include a saw assembly having an array of blades disposed in spaced-apart relation upon a shaft and configured to be driven at a cutting speed in a first rotational direction, the shaft defining a shaft interference zone; a feeder assembly configured to direct a flow of the wood chips along an endless feeder path, the endless feeder path comprising one or more either straight or curved segments, the feeder path passing into and through the array of blades, the feeder assembly defining a feeder zone at least partially intersecting the array of blades; a topper assembly positioned proximate the feeder path, the topper assembly located upstream of the saw assembly relative to the feeder path, the topper assembly configured to reduce the height of the flow of the wood chips such that the flow of wood chips does not tend to extend into the shaft interference zone, the topper assembly defining a topper zone, the apparatus reducing the wood chips into a plurality of cut chips.

In another aspect of the present invention, a control system for wood-reducing apparatus is disclosed. The system may include a saw load sensor operably connected to the saw assembly and configured to sense a saw load; a feeder load sensor operably connected to the feeder assembly and configured to sense a feeder load; a topper load sensor operably connected to the topper assembly and configured to sense a topper load; a chute load sensor operably connected to the chute and configured to sense a chute load; and a master controller operably connected to each of the respective sensors, each of the respective sensors capable of transmitting at least a normal signal and a fault signal.

In the exemplary control system, the master controller, in response to a fault signal from any of the respective sensors received at a start time, may (a) direct the

chute actuator to move the chute into the disengaged position, the disengaged position characterized by the chute guiding the wood chips away from the feeder assembly; and (b) direct the feeder assembly to drive the feeder assembly in the first rotational direction. The master controller, in response to a normal signal from each of the respective sensors received at an end time following the start time, may also (a) direct the chute actuator to move the chute into the engaged position; and (b) direct the feeder assembly to drive the feeder assembly in a direction generally opposing the first rotational direction.

Also, in the exemplary control system, the master controller, in response to a fault signal from any of the respective sensors received at a first time, may (i) direct the feeder assembly to pause the feeder assembly; (ii) direct the saw assembly to pause the saw assembly; and (iii) direct the topper assembly to pause the topper assembly. The master controller, in response to a normal signal from each of the respective sensors received at a second time following the first time, may also direct the feeder assembly, saw assembly, and topper assembly, respectively, to return to the normal operating condition..

In another aspect of the present invention, a method of reducing the size of wood chips is disclosed. The method may include directing a flow of the wood chips along a feeder path, the feeder path passing into and through a saw assembly, the saw assembly having an array of blades disposed upon a shaft and configured to be driven at a cutting speed in a first rotational direction, the shaft defining a shaft interference zone; providing a feeder assembly configured to direct the flow of the wood chips along the feeder path, the feeder assembly defining a feeder zone at least partially intersection the array of blades; and positioning a topper assembly proximate the feeder path, the topper assembly located upstream of the saw assembly relative to the feeder path, the topper assembly configured to reduce the height of the flow of the

wood chips such that the flow of wood chips does not tend to extend into the shaft interference zone, the topper assembly defining a topper zone.

The method may also include positioning the saw assembly such that the shaft interference zone nearly intersects tangentially with the feeder zone; and positioning the topper assembly such that the topper zone nearly intersects tangentially with the feeder zone.

The method may also include equipping the feeder assembly with one or more paddle assemblies configured to be driven along the feeder path at a feeder speed in a direction generally opposing the first rotational direction, each of the one or more paddle assemblies defining an array of slots therethrough; and positioning the slots to accept insertion of the array of blades.

The method may also include mounting the one or more paddle assemblies to an endless chain configured to be driven along an endless feeder path about one or more powered rollers, the endless feeder path comprising one or more either straight or curved segments, and the endless path coinciding with the feeder path at least during the flow through the array of blades.

The method may also include shaping the one or more paddle assemblies to align the wood chips generally transverse to the array of blades in preparation for the flow through the saw assembly; providing a scoop portion shaped to cradle the wood chips substantially within each of the one or more paddle assemblies; and providing a fence portion shaped to contain the wood chips substantially within each of the one or more paddle assemblies during the flow through the array of blades.

The method may also include equipping the topper assembly with one or more topper blades disposed upon a shaft and configured to be driven at a topping speed in the first rotational direction.

The method may also include providing a chute disposed in an engaged position to guide the flow of the wood chips toward the feeder assembly, the chute comprising a floor and a lower chute edge.

The method may also include providing a chute actuator configured to move the chute relative to the feeder assembly between the engaged position and a disengaged position, the disengaged position characterized by the chute guiding the wood chips away from the feeder assembly; operably connecting a chute controller to the chute actuator; locating a chute load sensor along the chute near the flow of wood chips, the chute load sensor capable of transmitting at least a normal signal and a fault signal; and operably connecting the chute load sensor to the chute controller.

The method may also include the chute actuator moving the chute into the disengaged position in response to a fault signal.

The method may also include positioning a dam between the chute and the feeder assembly, the dam shaped to urge the wood chips toward the feeder assembly; and shaping the dam to include an inner face oriented toward the feeder assembly, the inner face shaped to nearly coincide with the feeder zone, a trailing dam edge, and a leading dam edge.

The method may also include mounting the dam in a stationary location relative to the feeder assembly; positioning the dam such that the trailing dam edge nearly meets the lower chute edge when the chute is in the engaged position.

The method may also include, where the one or more paddle assemblies comprises an outer paddle face and a leading paddle edge, positioning the dam such that the outer paddle face nearly meets the inner dam face; and positioning the dam such that the leading paddle edge nearly meets the leading dam edge.

These and other objects, features, and advantages of the present invention will become apparent upon reading the following detailed description of a preferred embodiment of the invention when taken in conjunction with the drawing and the appended claims.

BRIEF DESCRIPTION OF THE DRAWING

The invention will be more readily understood by reference to the following description, taken with the accompanying drawing figures, in which:

Figure 1 is an illustration of a side elevation of an apparatus, according to one embodiment of the present invention.

Figure 2 is a schematic illustration of a side view of an apparatus, according to one embodiment of the present invention.

Figure 3 is a cross-sectional illustration of a saw assembly, according to one embodiment of the present invention.

Figure 4 is an illustration of a feeder assembly, according to one embodiment of the present invention.

Figure 5 is a schematic illustration of a control system, according to one embodiment of the present invention.

Figure 6 is an illustration of a side elevation of an apparatus in a disengaged position, according to one embodiment of the present invention.

Figure 7 is an illustration of a side elevation of an apparatus, according to one embodiment of the present invention.

Figure 8 is an illustration of an array of paddle members, according to one embodiment of the present invention.

Figure 9 is an illustration of a side elevation of an apparatus, according to one embodiment of the present invention.

DETAILED DESCRIPTION

The subject matter of this application is related to that of the following applications, each of which is incorporated herein by reference in its entirety: the U.S. Provisional Application bearing Serial No. 60/189,317, filed March 14, 2000; the U.S. Provisional Application bearing Serial No. 60/202,721, filed May 8, 2000; and the U.S. Non-Provisional Application bearing Serial No. 09/805,754, filed March 13, 2001, now U.S. Patent No. 6,575,066 B2.

1. Introduction

Exemplary systems, methods, and apparatuses are now described with reference to the drawings, where like reference numerals are used to refer to like elements throughout the several views. In the following description, for purposes of explanation, numerous specific details are set forth in order to facilitate a thorough understanding of the systems, methods, apparatuses, processes, and the like. It may be evident, however, that the systems, methods, apparatuses, processes, and the like can be practiced without these specific details. In other instances, well-known structures and devices are shown in block diagram form in order to simplify the description.

"Controller," as used herein, includes but is not limited to hardware, firmware, software and/or combinations of each to perform one or more functions or actions. For example, based upon a desired application or needs, a controller may include a software-controlled microprocessor, a Programmable Logic Controller (PLC), a discrete logic system such as an Application-Specific Integrated Circuit (ASIC), or other programmed logic device. The logic driving a controller may be fully embodied as software.

"Signal," as used herein, includes but is not limited to one or more electrical or optical signals, analog or digital, one or more computer instructions, a bit or bit stream, or the like.

"Sensor," as used herein, includes but is not limited to one or more elements capable of sensing or otherwise receiving current data or status information from a particular location. A sensor may be used, for example, to indicate equipment status such as feed rate, tool wear, loss of prime on pumps, motor load or amperage, mixer viscosity, the presence of metal objects, or any type of overload or under-load condition. A sensor may also include equipment for staging or timing the operation pump motors, conveyors, hoppers, and other machinery. A sensor may include a current transformer, transducer, relays, alarm circuits, contactors, and auxiliary contacts.

"Software," as used herein, includes but is not limited to, one or more computer readable and/or executable instructions that cause a computer, computer component, a controller such as a Programmable Logic Controller (PLC), and/or any other electronic device to perform functions, execute actions, receive and/or send signals, and/or behave in a desired manner. The instructions may be embodied in various forms like routines, algorithms, modules, methods, threads, ladder logic configurations, and/or programs. Software may also be implemented in a variety of executable and/or loadable forms including, but not limited to, a stand-alone program, a function call (local and/or remote), a servelet, an applet, instructions stored in a memory, part of an operating system or browser, and the like. It is to be appreciated that the computer readable and/or executable instructions can be located in one computer component and/or distributed between two or more communicating, co-operating, and/or parallel-processing computer components and thus can be loaded and/or executed in serial, parallel, massively parallel and other manners. It will be appreciated by one of ordinary skill in the art that the form of software may be dependent on, for example, requirements of a desired application, the environment in which it runs, and/or the desires of a designer or programmer or the like.

An "operable connection" (or a connection by which entities are "operably connected") is one in which signals, physical communication flow and/or logical

communication flow may be sent and/or received. Usually, an operable connection includes a physical interface, an electrical interface, and/or a data interface, but it is to be noted that an operable connection may consist of differing combinations of these or other types of connections sufficient to allow operable control.

"Data store," as used herein, refers to a physical and/or logical entity that can store data. A data store may be, for example, a database, a table, a file, a list, a queue, a heap, a sequential function table, structured text, a ladder logic list, and so on. A data store may reside in one logical and/or physical entity and/or may be distributed between two or more logical and/or physical entities.

Furthermore, to the extent that the term "includes" is employed in the detailed description or the claims, it is intended to be inclusive in a manner similar to the term "comprising" as that term is interpreted when employed as a transitional word in a claim. Further still, to the extent that the term "or" is employed in the claims (for example, A or B) it is intended to mean "A or B or both." When the author intends to indicate "only A or B but not both," the author will employ the phrase "A or B but not both." Thus, use of the term "or" herein is inclusive, not exclusive. *See* Garner, A Dictionary Of Modern Legal Usage 624 (2d ed. 1995).

It will be appreciated that some or all of the processes and methods of the system involve electronic and/or software applications that may be dynamic and flexible processes so that they may be performed in other sequences different than those described herein. It will also be appreciated by one of ordinary skill in the art that elements embodied as software may be implemented using various programming approaches such as machine language, procedural, ladder logic, structured text, and object-oriented and/or artificial intelligence techniques.

The processing, analyses, and/or other functions described herein may also be implemented by functionally equivalent circuits like a digital signal processor circuit, a software-controlled microprocessor, a Programmable Logic Controller (PLC), or an application-specific integrated circuit. Components implemented as software are not

limited to any particular programming language. Rather, the description herein provides the information one skilled in the art may use to fabricate circuits or to generate computer software to perform the processing of the system. It will be appreciated that some or all of the functions and/or behaviors of the present system and method may be implemented as logic as defined above.

Many modifications and other embodiments may come to mind to one skilled in the art who has the benefit of the teachings presented in the description and drawings. It should be understood, therefore, that the invention is not be limited to the specific embodiments disclosed and that modifications and alternative embodiments are intended to be included within the scope of the disclosure and the exemplary inventive concepts. Although specific terms may be used herein, they are used in a generic and descriptive sense only and not for purposes of limitation.

2. A Wood-Reducing Apparatus

Figure 1 illustrates an apparatus **10** having a saw assembly **80**, a feeder assembly **20**, and a topper assembly **70**. Generally described, the apparatus **10** according to the present invention may be configured to reduce wood chips known as overs **11** by cutting them into smaller chips for use in making paper, cardboard, and other recyclable materials. The overs **11** may take different shapes, including thin strips, generally-prismatic oblong segments, or any irregular shapes.

The apparatus **10** of the present invention may include a reciprocating or endless feeder path, meaning the apparatus **10** may process a continual flow of incoming overs **11**. The term continual is used herein because it implies a recurring event, as opposed to the term continuous, which implies an uninterrupted occurrence. The overs **11** may be supplied from the lumber mill or other wood processing facility in a generally continual flow, including periods where no overs **11** are incoming. The flow of incoming overs **11** may vary greatly in volume and duration, depending upon mill operations. The overs **11** in **Figure 1** are shown entering from above, generally, although the apparatus **10** may be configured to accept an incoming flow of overs **11** from any direction.

The apparatus **10** of the present invention provides the components and a control system capable of processing an incoming flow of overs **11** on a continual basis or on a batch basis. The apparatus **10** directs a flow of overs **11** through a saw assembly **80**, where the overs **11** are reduced into cut chips **13**. As used herein, the phrase "directs a flow" of overs **11** is meant to include receiving an incoming flow, re-directing an existing flow, or creating a new flow from a static collection of chips. **Figure 9** illustrates a flow of wood chips **11** through an apparatus **10**.

Beginning with entry of overs **11** into the area of the apparatus **10**, and referring to **Figure 1**, in one embodiment, the apparatus **10** may include a chute **60** to guide the overs **11** toward the feeder assembly **20**. The chute **60** may be moveable, to allow the apparatus **10** to direct the overs **11** away from the feeder assembly **20** if

and when a fault condition develops. The apparatus **10** may also include a dam **50** to urge the overs **11** into the feeder assembly **20**. The dam **50** may be moveable or stationary, or it may be an integral part of the chute **60**.

The feeder assembly **20** directs the overs **11** along a feeder path toward and through the saw assembly **80**. The feeder path may be generally circular, as shown in **Figure 1**, or it may take different forms, as shown in **Figure 7**. The feeder assembly **20** may be configured to rotate counter-clockwise with respect to the side view illustrated in **Figure 1**. The feeder assembly **20** traces an imaginary feeder zone **320** (shown in **Figure 2**) as it guides the overs **11** toward the saw assembly **80**.

In one embodiment, the feeder assembly **20** may include one or more paddle assemblies **40** disposed upon a rotating drum **30**. A paddle assembly **40** may include a series of discrete paddle members **440**, as shown in **Figure 8**. In this embodiment, the outermost surface of the paddle assemblies **40** trace the feeder zone **320**. Also, in this embodiment, each paddle assembly **40** may include an array of slots **45** such that the saw blades **83** extend into and pass through the slots **45** as the feeder assembly **20** moves past the saw assembly **80**. In one embodiment, the paddle members **440** are spaced apart, thereby forming the slots **45**, as shown in **Figure 8**. In one embodiment, the paddle members **440** are constructed of steel and machined to precise tolerances to create uniform slots **45** of a desired width (to produce a desired chip size).

In an alternative embodiment, the paddle assemblies **40** may be constructed of a high-density plastic material. In one embodiment, a method of preparing the paddles for use may include installing blank (un-slotted) paddles and moving the feeder assembly **20** slowly toward and through the saw assembly **80** such that the saw blades **83** themselves cut the paddle slots **45**. Allowing the saw blades **83** to cut their own corresponding slots **45** assures a good fit that is tailored to match the precise orientation of the saw blades **83**, without requiring precise attachment of the paddle assemblies **40** to the drum **30**.

Following the feeder path, as the feeder assembly **20** rotates, the overs **11** are directed first to the topper assembly **70**. In this aspect, the topper assembly **70** is generally upstream from the saw assembly **80**. The topper assembly **70** may be configured to rotate clockwise (opposing the rotation of the feeder assembly **20**) with respect to the side view illustrated in **Figure 1**. The topper assembly **70** traces an imaginary topper zone **370** (illustrated in **Figure 2**) as it rotates. The topper assembly **70** may include one or more topper blades disposed upon a topper shaft and driven at a topping speed. The topper blades may be disposed in a spiral about a topper drum or in any other configuration suitable for cutting. In an embodiment with topper blades, the outermost surface of the topper blades would trace the topper zone **370**.

Generally described, the topper assembly **70** removes excess overs **11** and/or cuts any portion of the overs **11** which may be extending beyond the feeder zone **320** (in other words, any overs **11** or any portion of the overs **11** extending to a height above the paddle assemblies **40** of the feeder assembly **20**). In this aspect, the topper assembly **70** may strike and remove entire wood chips out of a paddle assembly **40** as it passes. Those portions of the overs **11** which are cut and removed by the topper assembly **70** may be referred to as tops **12**. The excess overs **11** and tops **12** are removed at this point so they will not encroach upon or otherwise interfere with the shaft of the saw assembly **80**. The tops **12**, as shown, generally fall under the force due to gravity back toward the feeder assembly **20** to be captured and again directed toward the saw assembly **80**.

After a particular paddle assembly **40** passes near the topper assembly **70** and the excess overs **11** and/or tops **12** are removed, the feeder assembly **20** continues to guide the overs **11** toward and into the saw assembly **80**. In one embodiment, the saw assembly **80** may include a plurality of spaced-apart high-speed circular saw blades **83** mounted on a horizontal blade shaft **82** driven by a saw drive assembly. The saw assembly **80** may be configured to rotate clockwise (opposing the rotation of

the feeder assembly **20**) with respect to the side view illustrated in **Figure 1**. The saw assembly **80** traces an imaginary sawing zone **380** (shown in **Figure 2**) as the blades **83** rotate. Similarly, the saw blade shaft **82** traces an imaginary shaft interference zone **382** as it rotates. As mentioned above, the excess overs **11** and/or tops **12** are removed so they will not strike or otherwise interfere with the shaft **82**; in other words, so no portion of the overs **11** will enter the shaft interference zone **382**. In one embodiment, the saw blades **83** may be spaced apart by a plurality of saw blade spacers **84**.

Figure 3 is a cross-sectional illustration of a saw assembly **80** in one embodiment. The saw blades **83** may be horizontally stacked on a shaft **82** along with spacers **84** of appropriate thickness to produce a desired wood chip size. The saw blades **83** may be substantially planar and circular, and may include opposing saw blade keys cut into their center holes to provide an interlocking relationship with a pair of opposed blade shaft key slots on the blade shaft **82**. The interlocking keys and key slots may be provided to prevent the saw blades **83** from rotating relative to the blade shaft **82**.

In one aspect of the present invention, blades **83** and spacers **84** of various sizes may be provided and installed, to produce the desired chip size according to the intended use. The apparatus **10** may be configured with saws other than circular saws, including but not limited to band saws, jigsaws, chain saws, or other power saws. Saw blades **83** of any type may be used, without departing from the scope of the invention, to produce a desired chip size. Moreover, it should be understood that the saw blades **83** may be powered by devices other than the saw motor **830**, depending upon the particular saw type selected for the application.

The blade shaft **82** may include a solid shoulder **142** proximate one end with threads on the opposite end. The threaded end of the shaft may allow a large shoulder nut **143** to be tightened against an adjacent spacer **84**, causing the stacked spacers **84** and the saw blades **83** to be sandwiched together between the shoulder nut

143 and the shoulder **142**, and holding the saw blades **83** in place on the blade shaft **82** to be rotated therewith. The shoulder nut **143** not only provides a stop for the endmost spacer **84**, but also includes a pair of opposing flats which allow a wrench to grip the shaft **82** to control rotation thereof during assembly or disassembly. Journals near the ends of the blade shaft **82** for blade shaft bearings **420** with tapered bushings allow for easy removal of the bearings **420** (shown without frame supports for purposes of simplicity). A saw motor coupling **820** with a quick disconnect sleeve such as known in the art can be used.

Figure 7 illustrates another embodiment of an apparatus **10** having a saw assembly **80**, a feeder assembly **20**, and a topper assembly **70**, according to the present invention. The feeder assembly **20** may direct the overs through an irregular feeder path and, in turn, trace a feeder zone **320** such as the one shown in **Figure 7**. The embodiment shown also includes a chute **60** and a dam **50**. The feeder assembly **20** generally moves in a clockwise direction with respect to the view shown.

3. Zones of Interference

Figure 2 is a side view illustration of several three-dimensional reference zones traced by elements of an apparatus **10** according to one embodiment of the present invention. The zones traced are three-dimensional. A generally cylindrical element, for example, will trace a three-dimensional zone shaped like a cylinder. A generally planar body rotating on a lengthwise hinge, for example, may trace a zone in the shape of a sector of a cylinder, somewhat resembling the shape of a pie slice.

Generally, as mentioned above, the feeder assembly **20** traces an imaginary feeder zone **320** as it moves. A feeder zone **320** is illustrated in **Figure 2**. The saw assembly **80** traces a sawing zone **380**. The saw blade shaft **82** traces a shaft interference zone **382**. The topper assembly **70** traces a topper zone **370**.

In one embodiment, the topper assembly **70** is positioned relative to the other elements such that the topper zone **370** nearly intersects tangentially the feeder zone

320. In so doing, the topper assembly **70** is positioned so it will not interfere with the moving parts of the feeder assembly **20**. Also, the topper assembly **70** is positioned to remove any material that may tend to extend beyond the imaginary boundary created by the feeder zone **320**. Keeping material within the feeder zone **320** is a goal for this embodiment because the saw blade shaft **82** may be damaged by excess material.

The saw assembly **80** in one embodiment is also positioned relative to the feeder zone **320**. As shown, the shaft interference zone **382** also nearly intersects tangentially the feeder zone **320**. Also, as shown, for an embodiment where the feeder assembly **20** includes one or more paddle assemblies **40**, the sawing zone **380** may extend through nearly the full height of the paddle assemblies **40**. By positioning the saw assembly **80** in this location, the apparatus **10** takes advantage of the full cutting width of the saw blades **83**. Also, in this position, the saw assembly **80** will not interfere with the moving parts of the feeder assembly **20**.

The dam **50** in one embodiment may be positioned so that it nearly coincides with the feeder zone **320**. One of the roles of the dam **50** is to urge the overs **11** toward the feeder assembly so the overs **11** are nearly contained within the feeder zone **320** when they first enter the feeder assembly **20**. In this aspect, the dam **50** may reduce the burden on the topper assembly **70**. In an embodiment where the dam **50** may be part of the chute **60**, the chute **60** may be positioned such that the lower, dam portion of the chute **60** nearly coincides with the feeder zone **320**.

The chute **60** in one embodiment may be positioned so that its lower edge nearly intersects tangentially the feeder zone **320**. By positioning the chute **60** as shown, the lower edge guides overs into the space between the dam **50** and the feeder assembly **20**, such that the space lies generally within the feeder zone **320**. In this aspect, the chute position also contributes to keeping the overs within the feeder zone **320**.

The various positions are described as nearly tangential and nearly coinciding because a degree of separation or tolerance may exist between the elements of the apparatus **10** to allow relative movement and to prevent binding.

4. Guiding Overs Into a Feeder Assembly

Figure 4 is a side view illustrating a portion of an apparatus **10**, according to one embodiment. A portion of a feeder assembly **20** is shown; in particular, the embodiment that includes one or more paddle assemblies **40** disposed on a drum **30**. In one embodiment, as shown the apparatus **10** may include a chute **60** and a dam **50**, which may be an integral part of the chute **60** or a separate element.

Each paddle assembly **40**, in one embodiment, includes a scoop portion **44** and a fence portion **344**, as shown in **Figure 4**. Recall the paddle assembly **40** may include a series of paddle members **440**, as shown in **Figure 8**, wherein each paddle member **440** has the same shape such that, together, the series of paddle members **440** forms a paddle assembly **40** like the one shown in **Figure 1**. The scoop portion **44** generally holds a quantity of overs **11**, conveying them along the feeder path. The scoop portion **44** is shaped to contain the overs **11**; in three dimensions, the scoop portion **44** may be shaped like a trough. In one aspect, particularly for oblong overs, the scoop portion **44** may be shaped to align to the oblong overs in an orientation generally perpendicular to the blades **83** in the saw assembly **80**. In this aspect, the scoop portion **44** is shaped to align the oblong overs in preparation for cutting in a direction generally transverse to the longer lengthwise dimension of each wood chip.

The fence portion **344** extends away from the drum **30**, generally, on the open side of the scoop portion **44**. Referring again to **Figure 1**, the paddle assembly **40** that is passing through the saw assembly **80** shows one function of the fence portion **344** of each paddle assembly **40**. The fence portion **344** holds the overs **11** in place during the cutting process. As shown in **Figure 1**, the fence portion **344** is nearly radial with respect to the saw assembly. The nearly radial orientation of the fence

portion **344** effectively holds the overs during cutting and helps resists the force imparted to the overs **11** by the rotating blades of the saw assembly **80**. The force imparted may include not only the force exerted by the blades themselves, but also the wind or airflow creating by the saw assembly **80**. The fence portion **344** also resists the wind force, which may be particularly helpful when processing small or lightweight overs **11**.

Each paddle assembly **40** may also include an outer paddle face **43** and a leading paddle edge **42**, as shown in **Figure 4**, in one embodiment. The outer paddle face **43** may act as the surface which traces and nearly coincides with the feeder zone **320**. The outer paddle face **43** may also nearly coincide with the inner face **53** of the dam **50** as the paddle assemblies **40** moves along the feeder path. In conjunction with the leading paddle edge **42**, each paddle assembly **40** fits closely against the dam **50**.

The dam **50** in one embodiment may include an inner face **53** positioned toward the feeder assembly **20** and shaped to nearly match the feeder zone **320**. The dam **50** may have a leading edge **52** and a trailing edge **54**. The leading edge **52** is described as leading in reference to the direction of rotation of the feeder assembly **20**. In other words, the first edge met by the approaching paddle assembly **40** is the leading edge **52** of the dam **50**. Accordingly, the last edge is referred to as the trailing edge **54**.

The outer paddle face **43** and the leading paddle edge **42** may also pass very close to the lower edge **64** of the chute **60** in one embodiment. The lower chute edge **64** may nearly coincide with the trailing dam edge **54** so that, for example, none of the overs **11** pass between the chute **60** and the dam **50**. In one embodiment where the dam **50** is stationary and the chute **60** may be moved with respect to the feeder assembly **20**, the geometry of the lower chute edge **64** and the trailing dam edge **54** may be coordinated to avoid any interference between the dam **50** and the chute **60** when the chute **60** is in motion.

5. Automatic Redirection of Overs

Referring still to **Figure 4**, in one embodiment where the chute **60** may be moved with respect to the feeder assembly **20**, the position of the lower chute edge **64** nearly intersecting tangentially the feeder zone **320** represents one indication that the chute **60** is in the engaged position.

In one embodiment where the dam **50** is stationary and the chute **60** may be moved with respect to the feeder assembly **20**, the position of the lower chute edge **64** near the trailing dam edge **54** represents another indication that the chute **60** is in the engaged position.

The apparatus **10** of the present invention, in one embodiment, includes a chute **60** that may be placed in at least two positions: an engaged position **67** (as shown in **Figure 1**) and a disengaged position **68** (as shown in **Figure 6**). Generally, from the engaged position **67**, overs **11** are being guided into the feeder assembly **20**. From the disengaged position **68**, overs **11** are being guided away from the feeder assembly **20**.

Figure 6 shows the chute **60** in a disengaged position **68**. In the embodiment shown, the chute **60** is articulated about a hinge **62**, although other types of connections are contemplated. A chute actuator **65** may be provided to move the chute **60** to a desired position. In use, a chute actuator **65** may be a pneumatic or hydraulic cylinder, a chain drive, or any other motive means.

Moving the chute **60** to a disengaged position **68** ends the guidance of overs **11** toward the feeder assembly **20** and/or actively re-directs the flow of overs **11** away from the feeder assembly **20**. In one embodiment, the overs **11** may be collected and re-cycled back to a position before the apparatus **10**, where the overs **11** may re-enter the flow and eventually re-enter the apparatus **10**.

The chute **60** may be disengaged for any of a variety of conditions. In one embodiment, the apparatus **10** of the present invention includes a master controller

200 and a plurality of sensors, as shown schematically in **Figure 5**. The master controller **200** may be an analog or digital Programmable Logic Controller (PLC), a discrete logic system such as an Application-Specific Integrated Circuit (ASIC), or other programmed logic device. The master controller **200** may be used to receive sensor data and send signals to other controllers and assemblies, including on/off signals, timed notifications, and logic results. A master controller **200** in general may be programmed for on/off control, timing, logic, counting, and sequencing between and among multiple machines and elements in a system. A master controller **20** may use ladder logic, sequential function tables, software, databases, structured text, and/or any other type of programming capable of executing the desired instructions.

The master controller **200** may include one or more separate controllers for different elements, such as the ones shown in **Figure 5**: a chute controller **260**, a topper controller **270**, a saw controller **280**, and a feeder controller **220**. Also, the apparatus **10** of the present invention may include a chute actuator **65**, a topper drive assembly **75**, a saw drive assembly **85**, and a feeder drive assembly **25**.

The master controller **200** may receive input signals from one or more discrete sensors, including a feeder load sensor **26**, a saw load sensor **86**, a topper load sensor **76**. For an element driven by a motor, a load sensor may be installed such that it senses the amperage on the motor. A higher amperage may indicate an excessive drain on the motor, which in turn may indicate an excessive load. Similarly, a lower amperage may indicate a reduced or minimum load on the motor. In one embodiment of the present invention, the feeder load sensor **26**, saw load sensor **86**, and topper load sensor **76** are connected to the feeder drive assembly **25**, saw drive assembly **85**, and topper drive assembly **75**, respectively, and configured to sense the load on the respective motors. If the load sensed exceeds a set maximum, the load sensor sends a fault signal to the master controller **200**.

A master controller **200** may be programmed with rules to execute in response to any variety of conditions or modes, including normal, fault, emergency, slow, pause, or any combination of such modes. Also, for example, any variety of situations may represent a fault condition. Different situations may be programmed in the master controller **200** by writing instructions according to the logic rules governing the controller. Fault conditions may include jammed equipment, an undesirable object such as metal in the incoming flow, an overloaded motor or drive assembly, an under-loaded motor or drive indicating equipment is empty, or any combination of these factors on different elements or machines. A fault condition may also occur in response to a human input, such as pressing a fault button. The timing element in the master controller **200** allows a system to update its status based upon signals received when conditions change.

The master controller **200** may also receive input signals from a chute load sensor **66**. In one embodiment, the chute load sensor **66** may be a metal detector. If metal is detected anywhere in the incoming flow of overs **11**, the chute load sensor **66** may send a fault signal to the master controller **200**.

In response to a fault signal from any load sensor **26**, **86**, **76**, **66**, the master controller **200** may be programmed to send a signal directing the chute actuator **65** to move the chute **60** to a disengaged position. With the chute disengaged, as shown in **Figure 6**, the overs **11** may be allowed to fall outside the feeder assembly **20**. The master controller **200** may also be programmed to reverse the direction of rotation of the feeder assembly **20**, in order to unload all the overs **11**.

Disengaging the chute **60** in response to a fault condition prevents the introduction of additional overs **11** into the apparatus **10**. Reversal of the feeder assembly **20** in response to a fault condition unloads the current overs **11** from the apparatus **10**.

In a fault condition, the feeder assembly **20** may rotate in this reversed direction until the feeder load sensor **26** reading indicates an empty condition,

whereupon the master controller **200** may be programmed to return the apparatus **10** to normal operating mode.

6. Rest Mode

In one embodiment, the master controller **200** may be programmed to halt or pause the apparatus **10** when sensors indicate the incoming flow of overs **11** has stopped. In one embodiment of the present invention, the feeder load sensor **26**, saw load sensor **86**, and topper load sensor **76** are connected to the feeder drive assembly **25**, saw drive assembly **85**, and topper drive assembly **75**, respectively, and configured to sense the load on the respective motors. A low amperage on a motor may indicate a reduced or minimum load on the motor. If the load sensed is less than a set minimum, indicating the apparatus **10** is empty of overs, the load sensor sends a fault signal to the master controller **200**. In response, the master controller **200** may be programmed to stop driving and/or brake the active elements of the apparatus **10**.

The master controller **200** may be programmed to return the apparatus **10** to normal operating mode if and when a signal from any load sensor indicates the presence of overs **11** to be processed.

7. A Method

The present invention also provides a method of processing wood chips. In one embodiment, a method generally includes directing a flow of overs **11** along a feeder path and into and a saw assembly **80**. The method may include providing a feeder assembly to direct the overs **11** along the feeder path. The method may further include positioning a topper assembly **70** within the feeder path but in advance of the saw assembly **80**, such that the topper assembly **70** removes complete overs **11** or otherwise reduces any portion of the overs **11** that may tend to extend into a shaft interference zone **382**.

The method of the present invention may also include positioning the saw assembly **80** such that the shaft interference zone **382** nearly intersects tangentially with a feeder zone **320**. The method may further include positioning the topper assembly **70** such that the topper zone **370** nearly intersects tangentially with the feeder zone **320**.

An additional step may include equipping the feeder assembly **20** with one or more paddle assemblies **40**, each having an array of slots **45** therethrough positioned to accept insertion of the array of blades **83**. In another aspect of this step, the method may include shaping each paddle assembly **40** such that it aligns the overs **112** generally transverse to the array of blades **83** in preparation for cutting. Shaping each paddle assembly **40** may include providing a scoop portion shaped to cradle the overs **11** substantially within each paddle assembly and providing a fence portion shaped to contain the overs **11** substantially within each paddle assembly during cutting.

In one embodiment, the method may include mounting the paddle assemblies **40** to an endless chain driven along an endless feeder path about one or more powered rollers. The endless feeder path may include one or more either straight or curved segments.

8. Conclusion

The described embodiments of the invention are intended to be merely exemplary. Numerous variations and modifications will be apparent to those skilled in the art. All such variations and modifications are intended to fall within the scope of the present invention as defined in the appended claims.

What has been described above includes several examples. It is, of course, not possible to describe every conceivable combination of components or methodologies for purposes of describing the systems, methods, computer readable media and so on employed in planning routes. However, one of ordinary skill in the

art may recognize that further combinations and permutations are possible. Accordingly, this application is intended to embrace alterations, modifications, and variations that fall within the scope of the appended claims. Furthermore, the preceding description is not meant to limit the scope of the invention. Rather, the scope of the invention is to be determined only by the appended claims and their equivalents.

While the systems, methods, and apparatuses herein have been illustrated by describing examples, and while the examples have been described in considerable detail, it is not the intention of the applicants to restrict or in any way limit the scope of the appended claims to such detail. Additional advantages and modifications will be readily apparent to those skilled in the art. Therefore, the invention, in its broader aspects, is not limited to the specific details, the representative systems and methods, or illustrative examples shown and described. Accordingly, departures may be made from such details without departing from the spirit or scope of the applicant's general inventive concepts.